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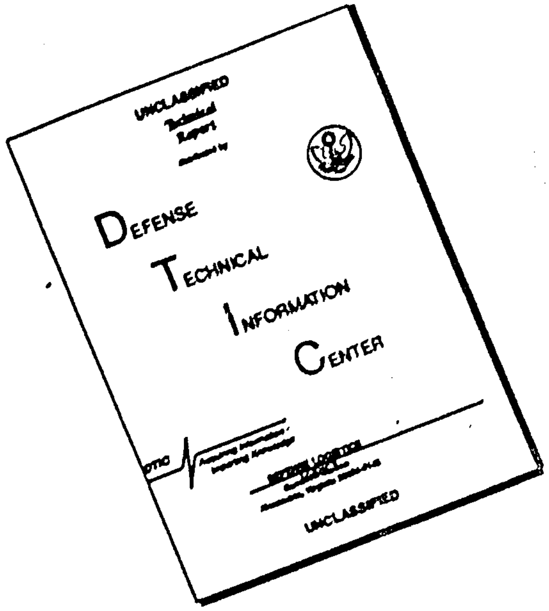

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WT-1309

OPERATION REDWING—PROJECT 1.10

BLAST OVER VEGETATED and CLEARED AREAS (U),

C. D. Broyles, [redacted]

Sandia Corporation
Albuquerque, New Mexico

FORMERLY RESTRICTED DATA

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FOREWORD

This report presents the results of one of the projects participating in the military-effect programs of Operation Redwing. Overall information about this and the other military-effect projects can be obtained from WT–1344, the "Summary Report of the Commander, Task Unit 3." This technical summary includes: (1) tables listing each detonation with its yield, type, environment, meteorological conditions, etc.; (2) maps showing shot locations; (3) discussions of results by programs; (4) summaries of objectives, procedures, results, etc., for all projects; and (5) a listing of project reports for the military-effect programs.

ABSTRACT

Measurements were made to determine the difference in blast effects over a surface covered with low shrubs and grass and over a cleared sandy surface in the precursor region, and an attempt was made to correlate this difference with measurements of preshock sound speed over the surface. Overpressure was measured with ground-baffle gages and with pitot-static gages at 3-foot elevation. Dynamic pressures were measured at the 3-foot elevation with the pitot-static gages. Measurements were made at the same ground ranges for vegetated surface as for the sandy surface. The vegetation reduced the severity of the precursor, showing later arrival times and smaller dynamic pressures than over the cleared area. The overpressures over the vegetation were the same at the ground and 3-foot levels. No measurements of sound speed after zero time were obtained, so a correlation is not possible.

CONTENTS

Chapter 1
INTRODUCTION

1.1 OBJECTIVE

The objective of this project was to determine the difference in the blast effects over a vegetated and over a sandy surface in the precursor region and, if possible, to correlate this difference with a difference in preshock sound speed.

1.2 HISTORY

Blast measurements have been made during most nuclear tests. The so-called precursor, a pressure wave that races ahead of the regular shock wave giving distorted pressure-time records, has been observed in many cases. Lowered overpressures and increased dynamic pressures characterize the precursor (References 1, 2, and 3). It generally occurs on shots with fairly low scaled burst heights—from less than 50 to about 600 feet. Since Operation Tumbler, it has generally been believed that precursor formation is due to a gaseous surface layer with a sound speed well above ambient. It is also generally accepted that this layer is caused by thermal radiation from the explosion.

Three methods by which the sound speed can be increased have been suggested: (1) the explosive liberation of water of hydration (the so-called popcorn effect) throws dust particles into the air, where they absorb thermal radiation and transfer it rapidly, because of the small size of the particles, to the air; (2) heat is transferred to the air by turbulent convective flow of the air; and (3) heating of the surface materials releases high sonic velocity gases, such as hydrogen.

The relative importance of these three methods probably varies with device yield, ground range, and type of surface; but the method of formation of the thermal layer is not at all understood (References 4, 5, 6, 7, and 8). Temperature measurements have indicated, in general, large temperature rises (up to 2,000 C) that return to nearly ambient before shock arrival. Sound-speed measurements have generally shown much lower increases in the sound speed or apparent temperature (only 100 C in many cases). During Operation Teapot, each type of measurement (References 7 and 8) gave about the same results over all of the surfaces (desert, asphalt, concrete, and vegetation), but the various types of measurements were in decided disagreement with each other. The low values of sound speed and temperature at precursor arrival were also in disagreement with the high temperatures inferred from the precursor velocities.

1.3 DEVELOPMENT OF EXPERIMENTAL PLANS

The need for a study of the effect of various surfaces on precursor formation was recognized several years ago. Plans were made to measure overpressure, dynamic pressure, and air temperature during Operation Castle on Site Pearl for Shot Echo, over a vegetated surface and over a sandy, cleared area. The shot was cancelled, however, so the study could not be carried out. Extensive studies were made in the precursor region over desert, asphalt, and water surfaces during Operation Teapot. Construction of a large vegetated area in the Nevada desert was not attempted, but small plots of various surfaces, including fir boughs and ivy, were instrumented for temperature and sound speed.

At the inception of Operation Redwing, a tower shot (Mohawk) was scheduled at the old Castle Echo site; therefore, a project similar to the Castle plans was proposed. Subsequently, Shot Inca was added to the Redwing schedule, and because of the small range in expected yield, Inca provided a much better shot on which to make these measurements. Therefore, Project 1.10 actually participated on Inca, rather than Mohawk.

Chapter 2
PROCEDURE and INSTRUMENTATION

2.1 INSTRUMENTS

Wiancko pressure gages mounted in ground baffles (Reference 9) and pitot-static gages mounted on 3-foot towers were used to measure the overpressure and dynamic pressure. The pitot-static gages were of the design used during Teapot (Reference 10), and utilized the same sensing head originally developed by Sandia Corporation (References 11 and 12) in a different supporting configuration.

Sound-speed gages were completely revised versions of the whistle gage tested during Operation Upshot-Knothole (Reference 12) and used during Teapot (Reference 13), but the principle of operation remained the same. In these gages air was drawn through an open-ended cavity in a manner that excited the natural acoustic frequency of the cavity. Since this frequency depended on the sound speed of the air, a record of frequency versus time could be easily converted to sound speed versus time. The cavity was made of barium titanate and acted as its own transducer. The frequency output of the cavity was amplified by a transistorized amplifier mounted at the gage, and the signal was fed directly to the magnetic-tape recording head.

2.2 RECORDING SYSTEM

The recording system was the same as that used on Project 1.2 for Shot Lacrosse. The pressure gages formed one arm of four-arm inductance bridges driven at 3 kc. Consolidated Type D System oscillator power supplies and amplifier-demodulators were used along with Ampex Model S-3439 magnetic tape recorders. Backup for the system was provided by the recording of each gage on two separate recorders.

2.3 GAGE CODE

Gages were given code designations for easy reference following the usual scheme, which employed: (1) a number taken from that of the station; (2) an abbreviation for the type of gage; (3) a number giving the height above ground for gages mounted in towers; and (4) a C or V to indicate whether the gage was in the cleared area or in the vegetation. Abbreviations used were GB for ground baffle; q and P for the dynamic pressure and the overpressure elements of the pitot-static gage; and S for the sound-speed gage.

2.4 LAYOUT

The layout on Site Pearl is shown in Figure 2.1. The pertinent details of the instrumentation, along with the predicted values of the blast parameters, are shown in Table 2.1. A yield of 7 kt was used for the predictions.

The project was planned as a minimum effort experiment; thus, no complete coverage versus distance was attempted, but it was felt that at least two stations over each surface were necessary to give sufficient reliance to the results in order that they be useful.

Exact positions of the gages were chosen by ground and air reconnaissance at the site to give continuous ground cover toward ground zero and still not have high bushes immediately in

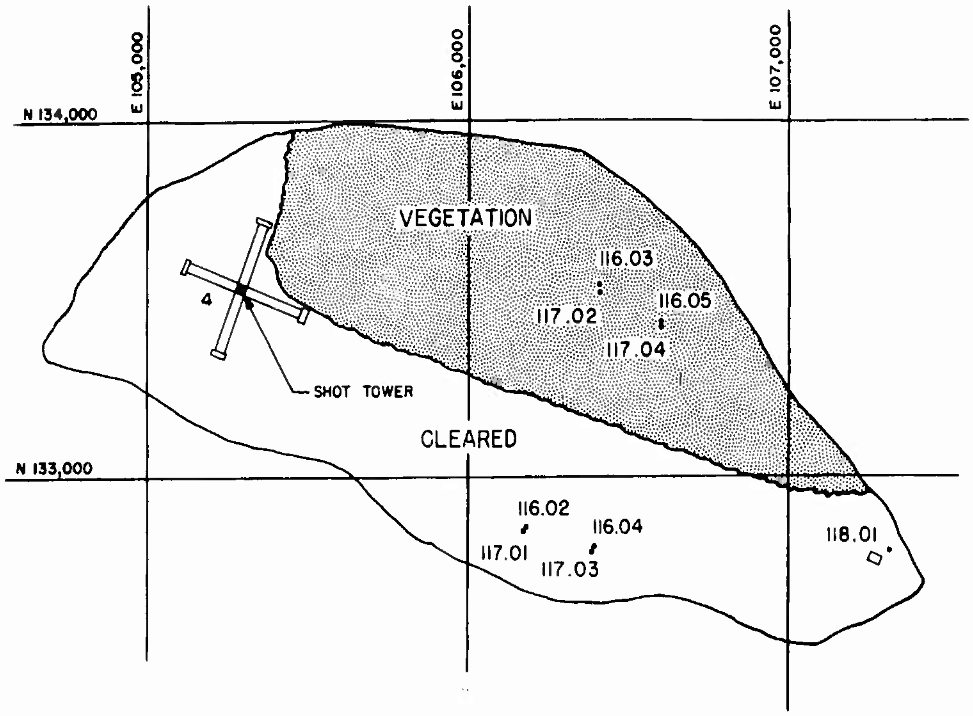

Figure 2.1 Gage layout for Shot Inca, Site Pearl.

TABLE 2.1 INSTRUMENTATION AND PREDICTED PARAMETERS FOR SHOT INCA

Station	Gage	Surface	Ground Range	Arrival Time	Over-pressure	Dynamic Pressure
			ft	sec	psi	psi
116.02	602GBC	Cleared	1114	0.21	27	78
117.01	701q3C, 701P3C, 701S3C	Cleared	1114	0.21	27	78
116.03	603GBV	Vegetation	1114	0.19	16	55
117.02	702q3V, 702P3V, 701S3V	Vegetation	1114	0.19	16	55
116.04	604GBC	Cleared	1309	0.288	19	45
117.03	703q3C, 703P3C, 703S3C	Cleared	1310	0.289	19	45
116.05	605GB	Vegetation	1309	0.268	13	21
117.04	704q3V, 704P3V, 704S3V	Vegetation	1309	0.268	13	21

front of the gages. This latter requirement was to give a few milliseconds of recording after shock arrival, during which it was known that missiles were not striking the gages.

The vegetation consisted of some vine (Ipomoea) and grass cover, plus almost complete coverage with broadleaf shrubs (Scaevola) 10 to 15 feet high. Figure 3.6 is an aerial photograph of the site taken before the shot.

The use of 7 kt for the planning yield gives a scaled height of burst of 105 feet. This is closer to the Upshot-Knothole Shot 1 conditions than Teapot Shot 12. However, Upshot-Knothole Shot 1 had much greater reductions in overpressures than any other shot. Also, precursor effects in the Pacific do not seem to be as strong as in Nevada. This is why Teapot Shot 12 overpressures, which were higher than Upshot-Knothole Shot 1, are used. Dynamic pressures in the precursor, on the other hand, do not seem to depend appreciably on the height of burst, so there is no difference in using Teapot Shot 12 rather than Upshot-Knothole Shot 1. The asphalt data were used for lack of any better. The vegetation should resemble the asphalt qualitatively in the production of smoke and vapors but may not reduce the amount of dust in the air as much.

These uncertainties in the phenomena must be combined with an uncertainty in the yield and in the capabilities of the transducer and recording system. With regard to the latter, a factor of about two greater than set range and a factor of about four smaller can be covered without loss of accuracy. Because of this limitation, set ranges were chosen somewhat higher than these predictions.

Chapter 3
RESULTS

The results for overpressures and dynamic pressures are given in Tables 3.1 and 3.2 and are presented versus ground range in Figures 3.3, 3.4 and 3.5. The values given contain no corrections for effect of Mach number on the gage reading. No results were obtained from the sound-speed gages after zero time. An examination of the transistorized amplifiers shows that the transistor gain had been reduced to such an extent that the amplifiers no longer functioned. The damage appears to be somewhat more severe than subsequent studies have shown is to be expected from nuclear radiation alone. The damage is probably a combination of effects of nuclear radiation and a large electromagnetic transient induced in the circuits at zero time.

The yield was actually 15 kt, instead of the 7 kt for which the experiment was planned. This, of course, means that the gages experienced larger pressures than expected; however, no malfunctioning or loss of information resulted.

3.1 OVERPRESSURES

Figure 3.1 gives a comparison of the overpressures to the desert and asphalt data from Teapot Shot 12, the latter scaled to 15 kt. An ideal 15-kt curve is shown. Two features of the data stand out. First, the ground-level pressures in the cleared area are much less than the 3-foot-level pressures, while in the vegetation they are about the same. Higher pressures above the ground than at ground level have often been measured in Nevada. The present data are too meager to permit a comparison between the Nevada and Pacific sites on the relative spread between the ground and above-ground measurements. The overpressures measured by the pitot-static gage have been calibrated in wind-tunnel tests and found to be high about 10 percent of the dynamic pressure for Mach 0.9 on axis flow. For upward flow expected during the first few milliseconds the gage may read low. Since this gage responds to dust in an unknown way, no good estimate of Mach number can be made. However, if the dynamic pressure is assumed to be all due to air and none to dust, an upper limit is found by calculating the Mach number M (Reference 10) from

$$\frac{P_p'}{P_s'} = \frac{q' + \Delta P' + P_o}{\Delta P' + P_o} = \left(1 + \frac{\gamma - 1}{2} M^2\right)^{\frac{\gamma}{\gamma - 1}}$$

where P_p' is as read total pressure and P_s' is the as read static pressure. Using the peak value of ΔP for gages 701 P3C and 702 P3V and measured q's at corresponding times, we find M = 0.65 and M = 0.95. Thus, since dust very apparently was contributing, the actual Mach number is lower than this and the correction is probably less than this 10 percent of q and cannot explain the difference between surface and 3-foot measurements. Second, the wave over the cleared area has a front porch,[1] while over the vegetation nothing that could really be called such is ap-

[1] By a "front porch" is meant a rise to an intermediate steady pressure preceding the main peak.

TABLE 3.1 OVERPRESSURE RESULTS

Station	Gage	Ground Range	Arrival Time	Precursor Pressure	Time of Precursor Pressure	Peak Pressure	Time of Peak Pressure	Peak Negative Pressure	Positive Pressure Duration	Negative Pressure Duration	Positive Pressure Impulse	Negative Pressure Impulse
		ft	sec	psi	sec	psi	sec	psi	sec	sec	psi-sec	psi-sec
116.02	602GBC	1114	0.224	17	0.232	36	0.259	2.8	0.41	2.4	3.9	3.3
117.01	701P3C	1114	0.225	33	0.233	53	0.260	2.1	0.45	2.6	5.0	4.4
116.03	603GBV	1114	0.241	17	0.246	46*	0.256	3.4	0.36	2.8	4.3	4.8
117.02	702P3V	1114	0.242	19	0.246	43†	0.264	3.2	0.36	2.8	4.3	3.9
116.04	604GBC	1309	0.330	‡	—	27	0.340	3.1	0.42	2.3	3.8	3.2
117.03	703P3C	1310	0.327	23	0.332	37	0.341	3.1	0.44	2.6	4.2	3.7
116.05	605GBV	1310	0.334	—	—	34§	0.356	2.0	0.58	2.6	4.4	3.2
117.04	704P3V	1309	0.340	¶	—	32**	0.353	2.7	0.48	2.2	4.2	3.7
118.01	801GBC	2130	0.819	—	—	16	0.823	1.3	0.67	2.2	3.3	2.4

* Secondary peak of 28 psi at 0.326 second.
† Secondary peak of 29 psi at 0.325 second.
‡ Initial fast rise of 25 psi.
§ Secondary peak of 22 psi at 0.424 second.
¶ Initial fast rise of 24 psi.
** Secondary peak of 22 psi at 0.432 second.

TABLE 3.2 DYNAMIC PRESSURE RESULTS

Station	Gage	Ground Range	Arrival Time	Precursor Pressure	Time of Precursor Pressure	Peak Pressure	Time of Peak Pressure	Positive Pressure Duration	Positive Pressure Impulse*
		ft	sec	psi	sec	psi	sec	sec	psi-sec
117.01	701q3C	1114	0.224	130	0.231	216†	0.242	0.65	7.0
117.02	702q3V	1114	0.242	80	0.247	94	0.256	‡	3.3
117.03	703q3C	1310	0.327	—	—	50§	0.335	0.37	2.4
117.04	704q3V	1309	0.339	—	—	40¶	0.346	‡	2.2

* Impulse from shock arrival to 0.2 second after shock arrival.
† Secondary peak of 56 psi at 0.289 second.
‡ Not readable.
§ Secondary peak of 32 psi at 0.364 second.
¶ Secondary peak of 17 psi at 0.427 second.

parent; rather, the wave is just a slow-rising pressure pulse. Arrival times bear out this observation, since arrival time is earlier in the cleared area than in the vegetation. However, the main peaks occ'.r at about the same time over both surfaces.

The scaled height of burst (yield, 15 kt) of this shot was about 80 feet, near the scaled heights of the Greenhouse Shots Dog and Easy. The pressure waves on those shots were also noted for the short length of their front porches and the early death of the precursors, as compared to Nevada shots.

3.2 DYNAMIC PRESSURES

The dynamic pressures are compared to the Teapot data in Figure 3.2, plotted against

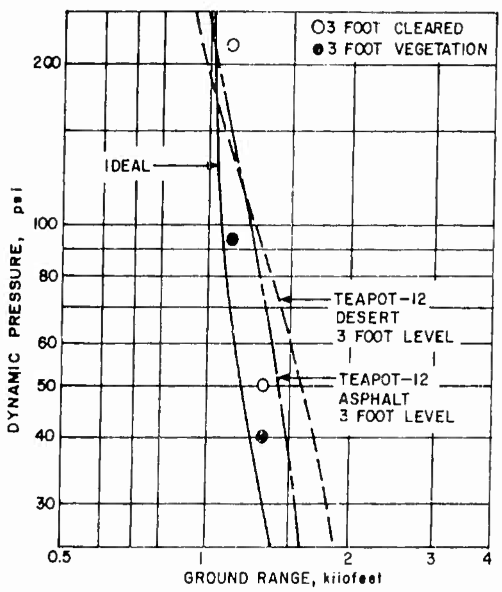

Figure 3.1 Overpressure versus ground range.

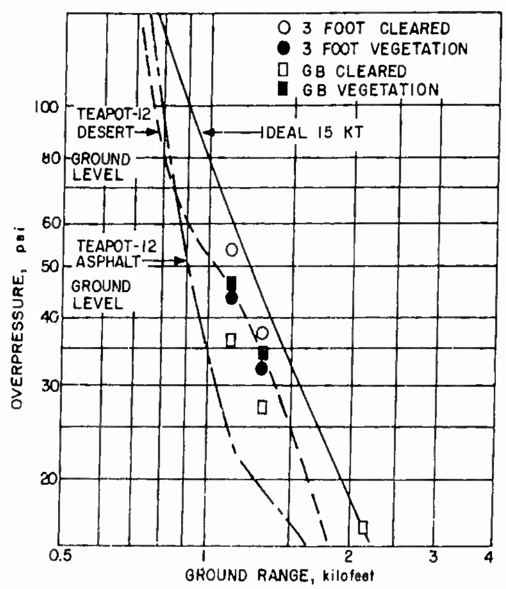

Figure 3.2 Dynamic pressure versus ground range.

ground range. The cleared area exhibited higher pressures than the vegetated area, particularly at the closer stations where the precursor was stronger. At the stations farthest from ground zero, the dynamic pressures were well below the Teapot curves, indicating an early cleaning up of the precursor.

At about 0.2 second after shock arrival at the two stations in the vegetation, an anomalous rise in the q records was observed (Figure 3.3). A check of the instrumentation indicated that these signals actually came from the gages but did not represent a real q but rather, as post-shot inspection showed, were caused by the pitot opening (the front opening on the gage) becoming clogged with dust and vegetation carried by the precursor. Since the side or static opening was not clogged, its pressure continued to drop, while the pressure at the front remained constant because of the plugging. This, of course, led to an increasing differential that was recorded as a q.

The dynamic-pressure measurements are reported as read with no corrections for Mach number characteristic of the gage. It has been pointed out in the AFSWP conference previously mentioned that with only the pitot tube no valid correction can be made because of the unknown

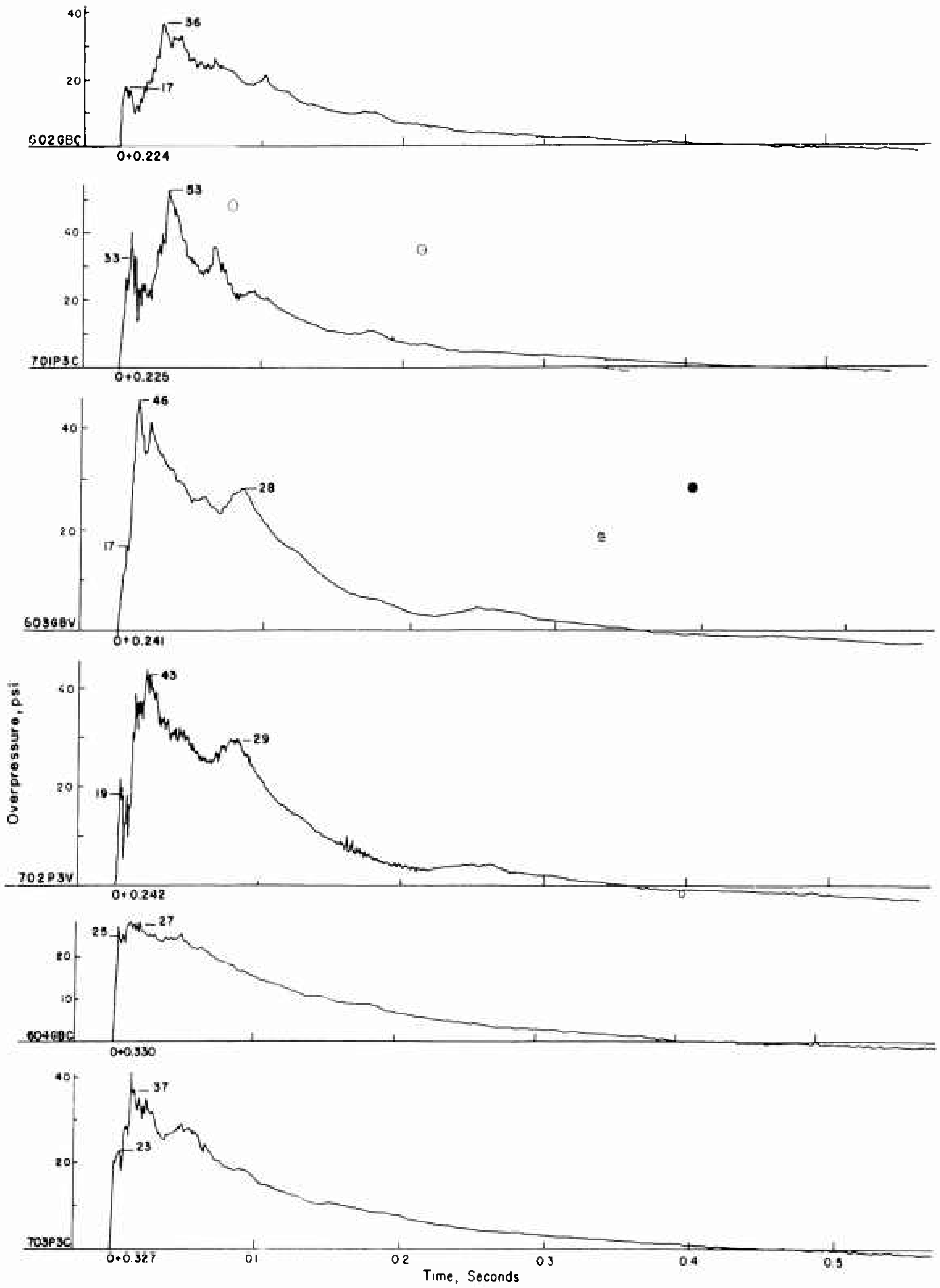

Figure 3.3 Overpressure versus time.

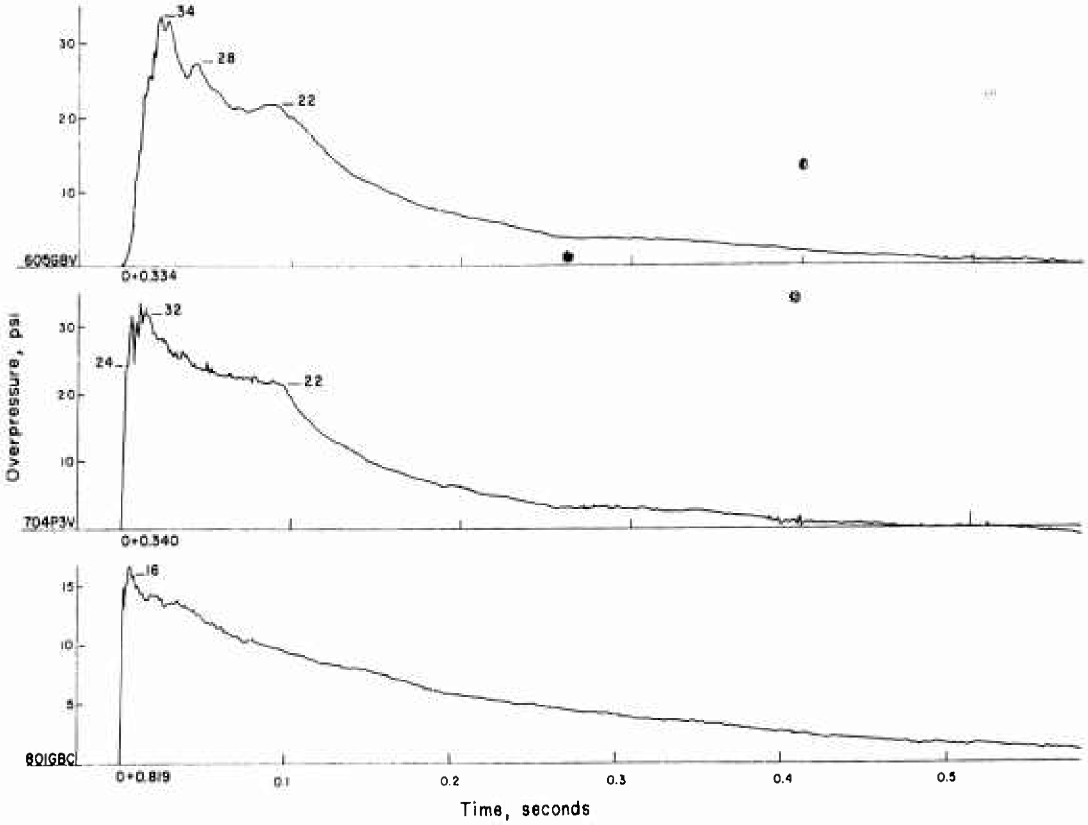

Figure 3.3 Continued.

effect of the dust, and in any case the upper limit of the correction has been shown to be small in the overpressure discussion.

3.3 EFFECT OF VEGETATION

Figure 3.6, taken before the shot, and Figure 3.7, a postshot photograph, emphasize the effect of the blast on the vegetation, with the island swept completely clear of all standing shrubs. Underfoot is a thick matting of dead sticks, vines, and grass in a sort of mulch mixed with sand. There is a definite lack of evidence of charred or burned material, indicating that whatever vegetation burned was blown clear of the island by the blast.

The precursor was weaker in the vegetation: Arrival times were later and overpressures in the vegetation were higher than ground-level pressures in the cleared area, though lower than the 3-foot pressures there. Dynamic pressures were less than over the cleared line.

All these differences must be attributed to the vegetation. The most interesting result is the fact that pressures at both levels in the vegetation were essentially the same. This was probably due to mechanical interaction of the vegetation with the shock, since the vegetation did provide almost continuous cover to a 10-foot height. The resulting turbulence could easily have produced a uniform layer at least 3 feet thick on the ground. An additional factor is that there may have been some uniformity even before shock arrival, because the foliage would have absorbed energy at various heights above the ground, promoting uniformity of itself and increasing turbu-

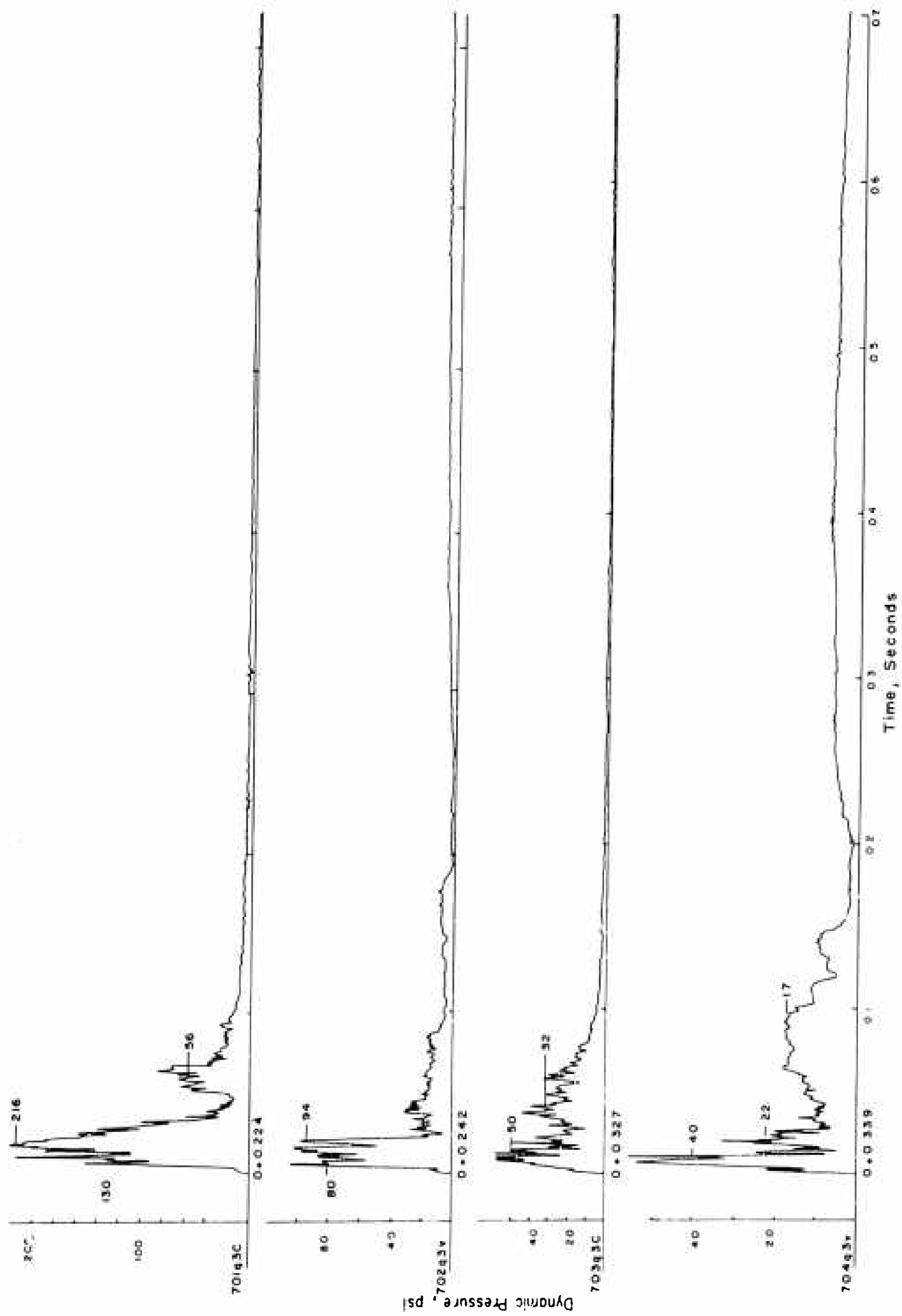

Figure 3.4 Dynamic pressure versus time.

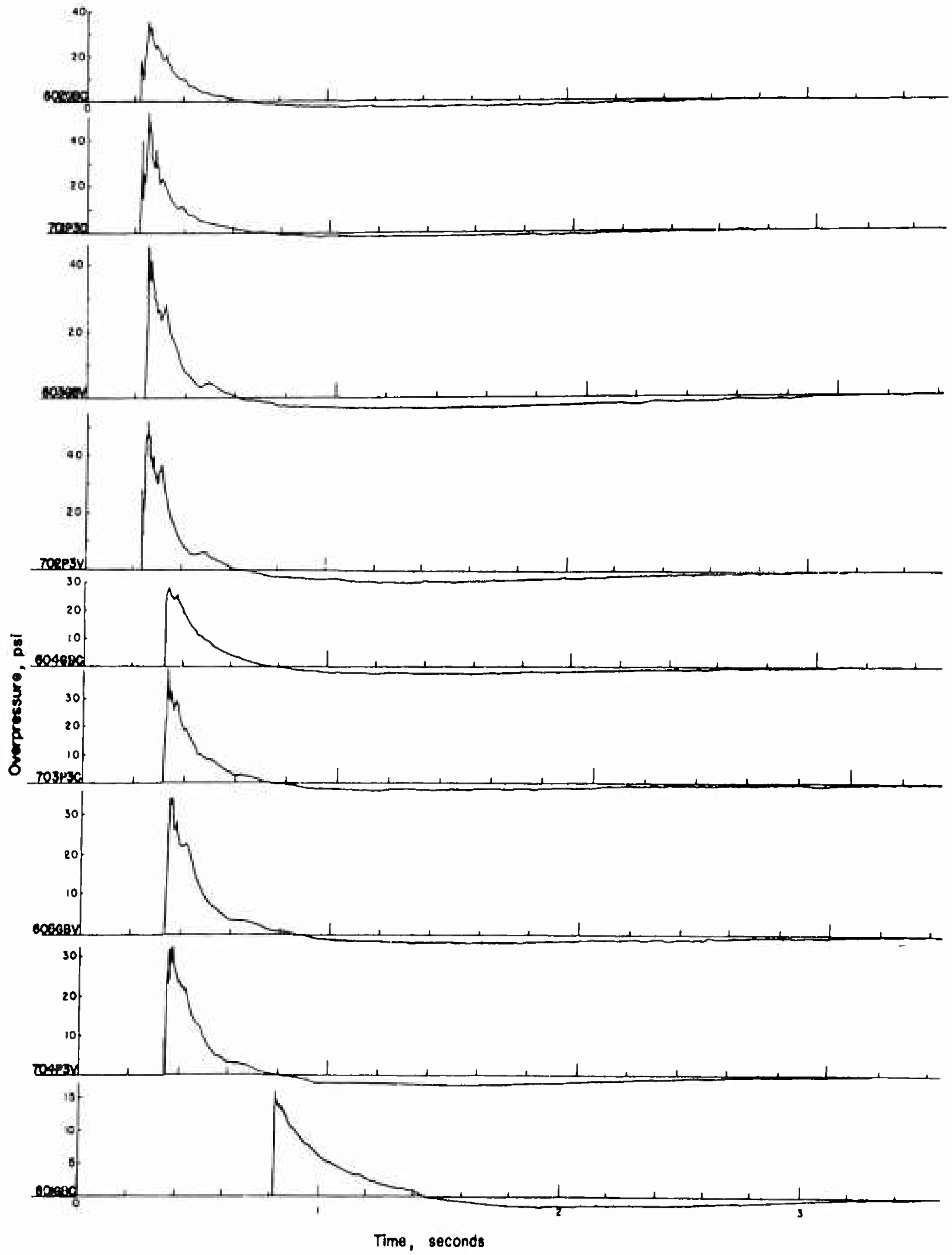

Figure 3.5 Overpressure versus time, reduced time scale.

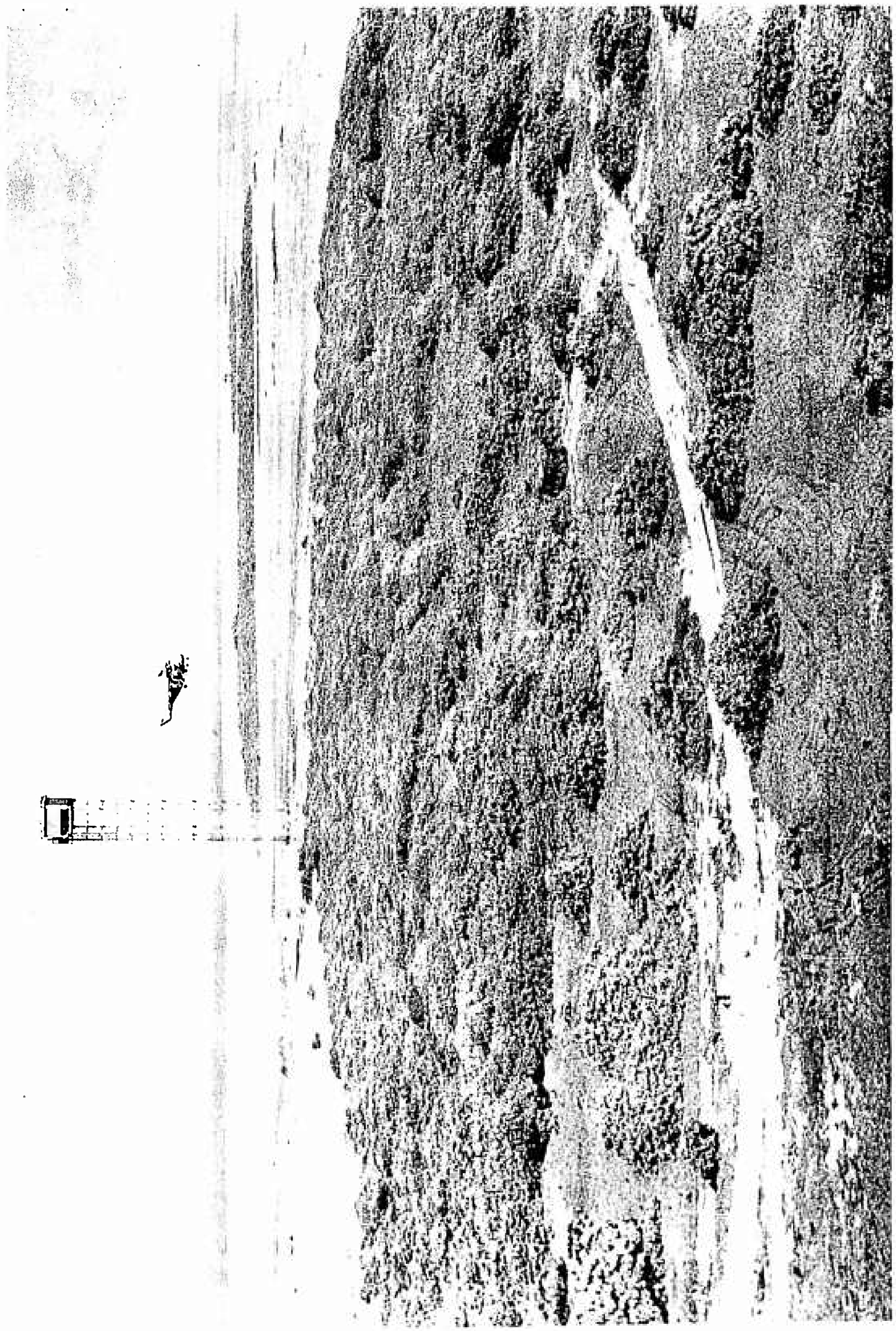

Figure 3.6 Site Pearl before Shot Inca.

Figure 3.7 Site Pearl after Shot Inca.

lent convection.

In Section 2.5, by analogy to Teapot Shot 12 asphalt and desert lines, a stronger precursor, i. e., earlier arrival times and lower overpressures, was predicted over the vegetation than over the cleared area. This analogy was used for lack of anything better. The experimental results did not follow this prediction, as has been pointed out above. The principal difference between the vegetation and the asphalt surfaces is the spatial extension of the vegetation above the surface. This affects the precursor growth, both by changing the distribution of the thermal energy deposition in the air and by providing a mechanical diffuser to slow down the wave and make the pressure through the vegetation layer uniform.

Projecting these results to other vegetated surfaces, it appears that qualitative prediction of precursor strength can be made on the basis of density, height, and strength of the vegetation.

Chapter 4
CONCLUSIONS

Vegetation consisting of grass, vines, and 10-foot shrubs reduced the severity of a precursor compared to one over a clear sandy surface. Overpressures were about the same at the ground and 3-foot levels in the vegetation, while over the cleared area the 3-foot level had much higher pressures than ground level. Overpressures in the vegetation were higher than ground-level pressures in the clear, but lower than 3-foot pressures there. Dynamic pressures were much reduced in the vegetation.

A qualitative prediction of precursor severity for various forms of vegetation can be made from these and Teapot results, i. e., the higher, denser, and stronger the vegetation, the weaker the precursor. With our, as yet, incomplete understanding of details of precursor phenomena, further measurements over other surfaces would be required if more quantitative predictions are required.

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34 Commanding Officer, Picatinny Arsenal, Dover, N.J. ATTN: ORDBB-TK

35 Commanding Officer, Diamond Ord. Fuze Labs., Washington 25, D.C. ATTN: Chief, Nuclear Vulnerability Br. (030)

36- 37 Commanding General, Aberdeen Proving Grounds, Md. ATTN: Director, Ballistics Research Laboratory

38 Commanding General, Frankford Arsenal, Bridge and Tacony St., Philadelphia, Pa.

39 Commander, Army Rocket and Guided Missile Agency, Redstone Arsenal, Ala. ATTN: Tech Library

40 Commanding General, White Sands Proving Ground, Las Cruces, N. Mex. ATTN: ORDBS-OM

41 Commander, Army Ballistic Missile Agency, Redstone Arsenal, Ala. ATTN: ORDAB-HT

42 Commanding General, Ordnance Tank Automotive Command, Detroit Arsenal, Centerline, Mich. ATTN: ORDMC-RO

43 Commanding General, Ordnance Weapons Command, Rock Island, Ill.

44 Commanding General, U.S. Army Electronic Proving Ground, Ft. Huachuca, Ariz. ATTN: Tech. Library

45 Commanding General, USA Combat Surveillance Agency, 1124 N. Highland St., Arlington, Va.

46 Director, Operations Research Office, Johns Hopkins University, 6935 Arlington Rd., Bethesda 14, Md.

47 Commander-in-Chief, U.S. Army Europe, APO 403, New York, N.Y. ATTN: Opot. Div., Weapons Br.

NAVY ACTIVITIES

48 Chief of Naval Operations, D/N, Washington 25, D.C. ATTN: OP-03EG

49 Chief of Naval Operations, D/N, Washington 25, D.C. ATTN: OP-36

50- 51 Chief of Naval Research, D/N, Washington 25, D.C. ATTN: Code 811

52- 53 Chief, Bureau of Aeronautics, D/N, Washington 25, D.C.

54- 58 Chief, Bureau of Aeronautics, D/N, Washington 25, D.C. ATTN: AER-AD-41/20

59 Chief, Bureau of Ordnance, D/N, Washington 25, D.C.

60 Chief, Bureau of Ships, D/N, Washington 25, D.C. ATTN: Code 423

61 Chief, Bureau of Yards and Docks, D/N, Washington 25, D.C. ATTN: D-440

62 Director, U.S. Naval Research Laboratory, Washington 25, D.C. ATTN: Mrs. Katherine H. Cass

63- 64 Commander, U.S. Naval Ordnance Laboratory, White Oak, Silver Spring 19, Md.

65 Director, Material Lab. (Code 900), New York Naval Shipyard, Brooklyn 1, N.Y.

66 Commanding Officer and Director, Navy Electronics Laboratory, San Diego 52, Calif.

67 Commanding Officer, U.S. Naval Mine Defense Lab., Panama City, Fla.

68- 69 Commanding Officer, U.S. Naval Radiological Defense Laboratory, San Francisco, Calif. ATTN: Tech. Info. Div.

70- 72 Officer-in-Charge, U.S. Naval Civil Engineering R&E Lab., U.S. Naval Construction Bn. Center, Port Hueneme, Calif. ATTN: Code 753

73 Commanding Officer, U.S. Naval Schools Command, U.S. Naval Station, Treasure Island, San Francisco, Calif.

74 Superintendent, U.S. Naval Postgraduate School, Monterey, Calif.

75 Commanding Officer, U.S. Fleet Sonar School, U.S. Naval Base, Key West, Fla.

76 Commanding Officer, U.S. Fleet Sonar School, San Diego 47, Calif.

77 Officer-in-Charge, U.S. Naval School, CEC Officers, U.S. Naval Construction Bn. Center, Port Hueneme, Calif.

78 Commanding Officer, Nuclear Weapons Training Center, Atlantic, U.S. Naval Base, Norfolk 11, Va. ATTN: Nuclear Warfare Dept.

79 Commanding Officer, Nuclear Weapons Training Center, Pacific, Naval Station, San Diego, Calif.

80 Commanding Officer, U.S. Naval Damage Control Tng. Center, Naval Base, Philadelphia 12, Pa. ATTN: ABC Defense Course

81 Commanding Officer, Air Development Squadron 5, VX-5, China Lake, Calif.

82 Director, Naval Air Experiment Station, Air Material Center, U.S. Naval Base, Philadelphia, Pa.

83 Commander, Officer U.S. Naval Air Development Center, Johnsville, Pa. ATTN: NAS, Librarian

84 Commanding Officer, U.S. Naval Medical Research Institute, National Naval Medical Center, Bethesda, Md.

85- 86 Commanding Officer and Director, David W. Taylor Model Basin, Washington 7, D.C. ATTN: Library

87 Commanding Officer and Director, U.S. Naval Engineering Experiment Station, Annapolis, Md.

88 Commander, Norfolk Naval Shipyard, Portsmouth, Va. ATTN: Underwater Explosions Research Division

89- 92 Commandant, U.S. Marine Corps, Washington 25, D.C. ATTN: Code AO3H

93 Commandant, U.S. Coast Guard, 1300 E. St., NW, W ngton 25, D.C. ATTN: (OIN)

94 Commanding Officer, U.S. Naval CIC School, U.S. Naval Air Station, Glynco, Brunswick, Ga.

AIR FORCE ACTIVITIES

95 Assistant for Atomic Energy, HQ, USAF, Washington 25, D.C. ATTN: DCS/O

96 Deputy Chief of Staff, Operations HQ. USAF, Washington 25, D.C. ATTN: Operations Analysis

97- 98 Assistant Chief of Staff, Intelligence, HQ. USAF, Washington 25, D.C. ATTN: AFCIN-IB2

99 Director of Research and Development, DCS/D, HQ. USAF, Washington 25, D.C. ATTN: Guidance and Weapons Div.

100 The Surgeon General, HQ. USAF, Washington 25, D.C. ATTN: Bio.-Def. Pre. Med. Division

101 Commander-in-Chief, Strategic Air Command, Offutt AFB, Neb. ATTN: OAWS

102 Commander, Tactical Air Command, Langley AFB, Va. ATTN: Doc. Security Branch

103 Commander, Air Defense Command, Ent AFB, Colorado. ATTN: Atomic Energy Div., ADLAN-A

104 Commander, Air Force Ballistic Missile Div. HQ. ARDC, Air Force Unit Post Office, Los Angeles 45, Calif. ATTN; WDSOT

105 Commander, Hq. Air Research and Development Command, Andrews AFB, Washington 25, D.C. ATTN: RDRWA

106-107 Commander, AF Cambridge Research Center, L. G. Hanscom Field, Bedford, Mass. ATTN: CRQST-2

108-112 Commander, Air Force Special Weapons Center, Kirtland AFB, Albuquerque, N. Mex. ATTN: Tech. Info. & Intel. Div.

113-114 Director, Air University Library, Maxwell AFB, Ala.

115 Commander, Lowry AFB, Denver, Colorado. ATTN: Dept. of Sp. Wpns. Tng.

116 Commandant, School of Aviation Medicine, USAF, Randolph AFB, Tex. ATTN: Research Secretariat

117 Commander, 1009th Sp. Wpns. Squadron, HQ. USAF, Washington 25, D.C.

118-120 Commander, Wright Air Development Center, Wright-Patterson AFB, Dayton, Ohio. ATTN: WCOSI

121-122 Director, USAF Project RAND, VIA: USAF Liaison Office, The RAND Corp., 1700 Main St., Santa Monica, Calif.

123 Commander, Rome Air Development Center, ARDC, Griffiss AFB, N.Y. ATTN: The Documents Library, RCSSLD

124 Assistant Chief of Staff, Intelligence, HQ. USAFE, APO 633, New York, N.Y. ATTN: Directorate of Air Targets

125 Commander-in-Chief, Pacific Air Forces, APO 953, San Francisco, Calif. ATTN: PFCIE-MB, Base Recovery

OTHER DEPARTMENT OF DEFENSE ACTIVITIES

126 Director of Defense Research and Engineering, Washington 25, D.C. ATTN: Tech. Library

127 Chairman, Armed Services Explosives Safety Board, DOD, Building T-7, Gravelly Point, Washington 25, D.C.

128 Director, Weapons Systems Evaluation Group, Room 1E880, The Pentagon, Washington 25, D.C.

129-136 Chief, Defense Atomic Support Agency, Washington 25, D.C.

137 Commander, Field Command, DASA, Sandia Base, Albuquerque, N. Mex.

138 Commander, Field Command, DASA, Sandia Base, Albuquerque, N. Mex. ATTN: FCTG

139-143 Commander, Field Command, DASA, Sandia Base, Albuquerque, N. Mex. ATTN: FCWT

144 Commander, JTF-7, Arlington Hall Station, Arlington 12, Va.

145 Administrator, National Aeronautics and Space Administration, 1520 "H" St., N.W., Washington 25, D.C. ATTN: Mr. R. V. Rhode

146 U.S. Documents Officer, Office of the United States National Military Representative - SHAPE, APO 55, New York, N.Y.

ATOMIC ENERGY COMMISSION ACTIVITIES

147-149 U.S. Atomic Energy Commission, Technical Library, Washington 25, D.C. ATTN: For DMA

150-151 Los Alamos Scientific Laboratory, Report Library, P.O. Box 1663, Los Alamos, N. Mex. ATTN: Helen Redman

152-166 Sandia Corporation, Classified Document Division, Sandia Base, Albuquerque, N. Mex. ATTN: H. J. Smyth, Jr.

167-169 University of California Lawrence Radiation Laboratory, P.O. Box 808, Livermore, Calif. ATTN: Clovis G. Craig

170 Weapon Data Section, Technical Information Service Extension, Oak Ridge, Tenn.

171-205 Technical Information Service Extension, Oak Ridge, Tenn. (Surplus)